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April 15, 1993
Project Number K103101

Barneys Canyon Mine
P.O. Box 311
Bingham Canyon, Utah
84006-0311

By FAX

Attention: Mr. Dave Hodson

Dear Mr. Hodson:

RE: SUMMARY OF ABA ACCOUNTING RESULTS FROM THE MELCO DEPOSIT

This letter summarizes the testing results from 55 samples collected from the Melco deposit.

A total of 10 drill core samples from each of the major rock units were collected and submitted for testing.
The rock units comprise:

- non-calcareous sandstone;
- calcareous sandstone;
- quartzite;
- carbonaceous dikes; and,
- sulfide rock;

Five samples were also collected from a breccia zone in the waste rock.

The proportion of each of these materials is currently under assessment by Barneys Canyon Mine personnel. It is estimated that the carbonaceous and sulphitic rock will comprise less than 5 percent of the total waste dump composition. Table 1 lists the drill holes and depths at which each of the samples was collected.

The samples were submitted to Core Laboratories in Aurora, Colorado for acid base accounting tests.



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Acid Base Accounting Results

Acid base accounting tests are used to define the balance between potentially acid generating minerals (sulphides) and acid consuming minerals (typically carbonates). Table 1 presents the acid base accounting test results for each of the 55 samples. These are discussed by rock type below.

Non-Calcareous Sandstone

The non-calcareous sandstone is relatively "barren" with respect to sulphide and carbonate mineralization. Sulphur levels do not exceed 0.01 percent (the detection limit), and therefore do not have any significant potential to oxidize and produce acidity. The neutralization potential (NP) of the samples is typically very low, ranging from 0.9 to 4.1 kg CaCO₃ equivalent/tonne, and a single sample with an NP of 22.5. The average NNP from the 10 samples tested was 3.9. These samples are essentially inert and would not contribute acidity to the rock pile, nor do they contain sufficient NP to neutralize acidity generated from other rock types within the pile.

Barneys Canyon Mine have reported that a significant portion of the dumps will be comprised of the non-calcareous sandstone.

Calcareous Sandstone

Sulphur levels in the calcareous sandstone samples are very low, less than 0.01 percent. This material is therefore unlikely to oxidize or produce acidity. The neutralization potential ranges from <0.1 to 98.4 kg CaCO₃ equivalent/tonne, with an average value of 41.8. Rock from this unit can be classified as acid consuming.

No estimate of the proportion of calcareous sandstone has been made.

Quartzite

The sulphur content of the 10 quartzite samples is very low, ranging from <0.01 to 0.02 percent. The neutralization potential is also relatively low, ranging from 0.9 to 36.4 kg CaCO₃ equivalent/tonne. Six of the samples are in the range of 0.9 to 3.4 kg CaCO₃ equivalent/tonne, and are considered non-reactive. The remaining 4 samples contain 21.7 to 36.4 kg CaCO₃ equivalent/tonne NP, and are considered acid consuming.

A significant portion of the dumps will be comprised of the quartzite.

Carbonaceous Dikes

The carbonaceous material contains a significant proportion of sulphide mineralization. Total sulphur levels range from 0.05 to 4.05 percent. Sulphate levels are low, ranging from <0.01 to 0.18 percent. Assuming the total sulphur less the sulphate sulphur is equivalent to the sulphide sulphur content, the sulphide content ranges from 0.03 to 3.9 percent, and has an average value of 1.25.

The NP measured in this material ranges from <0.1 to 4.6, indicating a low acid neutralization potential. The majority of samples are considered likely to generating acid. Two of the sample are in the uncertain range, where kinetic tests are required to determine the likelihood for acid generation.

It is possible that the sulphide sulphur, or AP, content is actually somewhat less than reported. If some of the sulphur is present as barite, it will report to the sulphide sulphur, thus overestimating the potential for acid production. As discussed, we have initiated work to quantify the amount of barite, and recalculate the AP.

Barneys Canyon Mine have indicated that less than 1 percent of this material will report to the waste dumps.

Sulphide rock

The sulphur content of this material ranges from 0.04 to 2.6 percent. Sulphates range from <0.01 to 0.14. Assuming sulphide content is equivalent to the total sulphur less the sulphate sulphur (see the previous comment on barite), the sulphide content is in the range of <0.01 to 2.46, with an average of 0.93 percent. Five of the samples contain less than 2 kg CaCO₃ equivalent/tonne NP, while 5 are in the range of 9.1 to 38.5 kg CaCO₃ equivalent/tonne NP. Six of the samples are considered likely to produce acidity. Three are in the range of uncertainty for acid generation, and one sample is considered acid consuming.

Barneys Canyon Mine have indicated that less than 4 percent of the sulphide rock will report to the waste dumps.

Note. This should read less than 4 percent of the dump material will contain sulfide.

Breccia

Five samples from the breccia rock were tested. Sulphide contents range from <0.01 to 0.09 percent, indicating a relatively low potential to generate acidity. The NP of these samples range from 2.3 to 9.7 kg CaCO_3 equivalent/tonne NP. The samples do not have a clear potential to either generate or consume acidity.

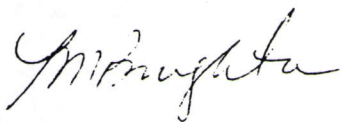
No estimate of the proportion of breccia has been made.

Overall Acid Potential

Table 2 provides an estimate of the acid generation potential for the dumps, assuming the majority of the material is comprised of non-calcareous sandstone and quartzite. This will be refined once the results of the block model are available to us. The percentages assume a worse case, in that the calcareous sandstone is probably under-represented in the composition. Assuming these samples adequately represent each of the rock units, it is considered unlikely that the pile could generate acid. There is however a potential for the release of sulphate if the carbonaceous and sulphitic rocks oxidize. Strategies for placement of these materials, and a risk analysis comparing the alternatives will be sent to you within the next week.

Yours truly,

STEFFEN ROBERTSON AND KIRSTEN (CANADA) INC.



for A. MacG. Robertson, P.Eng.
Principal

attach.

KSS/LMB/AMR
073/AMR

TABLE 1
Melco Deposit - Acid Base Accounting Test Results

Sample	Depth From	Depth To	S (tot)	S (SO4)	S (S2-)	AP	NP	NNP	NP/AP Notes
MC-280D	504	514	<0.01	0.02	<0.01	<0.3	4.4 >	4.1 >	14.5 Non-calcareous Sandstone
MC-281D	115	125	<0.01	0.02	<0.01	<0.3	1.1 >	0.8 >	3.6 Non-calcareous Sandstone
MC-319D	10	20	<0.01	<0.01	<0.01	<0.3	0.2 >	-0.1 >	0.7 Non-calcareous Sandstone
MC-352P	775	780	0.01	<0.01	0.01	0.3	1.4	1.1	4.5 Non-calcareous Sandstone
MC-353D	20	30	<0.01	0.02	<0.01	<0.3	0.9 >	0.6 >	3.0 Non-calcareous Sandstone
MC-361D	260	265	<0.01	<0.01	<0.01	<0.3	2.2 >	1.9 >	7.3 Non-calcareous Sandstone
MC-361D	390	395	0.01	0.04	<0.01	<0.3	2.8 >	2.5 >	9.2 Non-calcareous Sandstone
MC-363P	690	700	<0.01	<0.01	<0.01	<0.3	22.8 >	22.5 >	75.2 Non-calcareous Sandstone
MC-374D	383	393	<0.01	<0.01	<0.01	<0.3	1.6 >	1.3 >	5.3 Non-calcareous Sandstone
MC-377D	10	30	<0.01	0.02	<0.01	<0.3	1.6 >	1.3 >	5.3 Non-calcareous Sandstone
MC-280D	49	54	<0.01	0.03	<0.01	<0.3	82 >	81.7 >	270.6 Calcareous Sandstone
MC-280D	164	174	<0.01	0.02	<0.01	<0.3	<0.1 >	-0.3	0.0 Calcareous Sandstone
MC-280D	334	341	<0.01	0.03	<0.01	<0.3	68.3 >	68.0 >	225.4 Calcareous Sandstone
MC-281D	715	720	<0.01	<0.01	<0.01	<0.3	98.4 >	98.1 >	324.7 Calcareous Sandstone
MC-319D	80	90	<0.01	<0.01	<0.01	<0.3	0.6 >	0.3 >	2.0 Calcareous Sandstone
MC-319D	90	100	<0.01	<0.01	<0.01	<0.3	<0.1 >	-0.3 >	0.0 Calcareous Sandstone
MC-361D	130	135	<0.01	<0.01	<0.01	<0.3	3.4 >	3.1 >	11.2 Calcareous Sandstone
MC-361D	225	230	<0.01	0.02	<0.01	<0.3	23.2 >	22.9 >	76.6 Calcareous Sandstone
MC-361D	215	220	<0.01	<0.01	<0.01	<0.3	1 >	0.7 >	3.3 Calcareous Sandstone
MC-363P	615	625	<0.01	<0.01	<0.01	<0.3	140 >	139.7 >	462.0 Calcareous Sandstone
MC-280D	820	830	<0.01	<0.01	<0.01	<0.3	21.7 >	21.4 >	71.6 Quartzite
MC-281D	295	300	0.01	<0.01	0.01	0.3	26.4	26.1	84.5 Quartzite
MC-281D	400	410	<0.01	<0.01	<0.01	<0.3	1.2 >	0.9 >	4.0 Quartzite
MC-319D	485	490	0.01	<0.01	0.01	0.3	3.4	3.1	10.9 Quartzite
MC-252P	705	710	<0.01	0.04	<0.01	<0.3	2.4 >	2.1 >	7.9 Quartzite
MC-353D	305	310	<0.01	<0.01	<0.01	<0.3	2.6 >	2.3 >	8.6 Quartzite
MC-361D	735	740	<0.01	0.02	<0.01	<0.3	2.6 >	2.3 >	8.6 Quartzite
MC-363P	578	580	<0.01	<0.01	<0.01	<0.3	24.2 >	23.9 >	79.9 Quartzite
MC-374D	173	183	0.02	0.04	<0.01	<0.3	36.4 >	36.1 >	120.1 Quartzite
MC-377D	101	110	<0.01	<0.01	<0.01	<0.3	0.9 >	0.6 >	3.0 Quartzite
MC-280D	798	801	0.53	0.09	0.44	13.8	0.9	-12.9	0.1 Carbonaceous Dikes
MC-319D	385	390	1.21	0.18	1.03	32.2	<0.1	-32.2	0.0 Carbonaceous Dikes
MC-319D	390	395	0.85	0.16	0.69	21.6	<0.1	-21.6	0.0 Carbonaceous Dikes
MC-319D	400	405	0.07	0.04	0.03	0.9	1.2	0.3	1.3 Carbonaceous Dikes
MC-319D	695	700	0.05	<0.01	0.05	1.6	2	0.4	1.3 Carbonaceous Dikes
MC-319D	820	825	1.82	0.17	1.65	51.6	<0.1	-51.6	0.0 Carbonaceous Dikes
MC-353D	784	790	0.51	0.03	0.48	15.0	3	-12.0	0.2 Carbonaceous Dikes
MC-377D	483	491	3.17	0.18	2.99	93.4	<0.1	-93.4	0.0 Carbonaceous Dikes
MC-377D	906	911	1.27	<0.01	1.27	39.7	<0.1	-39.7	0.0 Carbonaceous Dikes
MC-377D	911	917	4.05	0.15	3.9	121.9	4.6	-117.3	0.0 Carbonaceous Dikes
MC-319D	995	1000	1.78	<0.01	1.78	55.6	1.6	-54.0	0.0 Sulphide Rock
MC-319D	1000	1005	0.98	0.14	0.84	26.3	<0.1	-26.3	0.0 Sulphide Rock
MC-352P	1005	1010	2.6	0.14	2.46	76.9	<0.1	-76.9	0.0 Sulphide Rock
MC-352P	1060	1065	1.09	0.05	1.04	32.5	38.5	6.0	1.2 Sulphide Rock
MC-353D	970	975	0.45	0.2	0.25	7.8	9.3	1.5	1.2 Sulphide Rock
MC-353D	990	995	0.07	0.02	0.05	1.6	<0.1	-1.6	0.0 Sulphide Rock
MC-353D	1025	1030	0.04	0.04	<0.01	<0.3	29.7 >	29.4 >	98.0 Sulphide Rock
MC-361D	792	797	1.23	0.03	1.2	37.5	9.1	-28.4	0.2 Sulphide Rock
MC-361D	820	825	0.41	0.03	0.38	11.9	16	4.1	1.3 Sulphide Rock
MC-377D	980	990	1.3	0.02	1.28	40.0	0.5	-39.5	0.0 Sulphide Rock
MC-319D	750	755	0.09	<0.01	0.09	2.8	9.7	6.9	3.4 Breccia
MC-352P	830	835	<0.01	0.02	<0.01	<0.3	3 >	2.7 >	9.9 Breccia
MC-361D	680	684	0.13	<0.01	0.13	4.1	3.5	-0.6	0.9 Breccia
MC-374D	272	282	0.1	<0.01	0.1	3.1	5.3	2.2	1.7 Breccia
MC-377D	815	825	<0.01	<0.01	<0.01	<0.3	2.3 >	2.0 >	7.6 Breccia

TABLE 2
Summary Results

Rock Unit	avg AP	avg NP	avg NNP	avg NP/AP	% in rock piles
Breccia	2.0	4.8	2.8	2.4	1
Calcareous Sandstone	<0.3	41.7	41.7	> 139.0	1
Carbonaceous Dikes	39.2	1.2	-38.0	0.0	1
Non-calcareous Sandstone	<0.3	3.9	3.9	> 13.0	44
Quartzite	0.1	12.2	12.1	194.9	45
Sulphide Rock	29.0	10.5	-18.5	0.4	4
Overall Weighted Average	1.6	8.1	6.5	5.1	

2. PIT HIGHWALLS

At the end of the mine life there will be sulfide waste exposed on the high walls at both Barneys Canyon and the Melco pits.

At Barneys Canyon the sulfide is relatively unreactive, is immediately buffered by the excess neutralizing capacity of the host rock and will in the course of time be submerged by water as the natural groundwater table is re-established. This sulfide will not then oxidize and thus will not be of concern. At the Melco pit the sulfide will remain exposed and it is likely that a small quantity of acid runoff will occur during rainfall events at least until the exposed surface has fully oxidized. Barneys Canyon staff are currently working with consultants to evaluate the potential of "sealing" the sulfide surface with a calcium silicate coat which will prevent oxidation of the sulfides. A report on this study should be available by end 1993.

In any case the quantity of acid runoff is likely to be small and short lived and it can be controlled by placing limestone or dolomite in the pit bottom to effect neutralization of the runoff.

3. SULFATE MOBILIZATION

Sulfate is a secondary concern which is evaluated in connection with potential acid mine drainage or with naturally occurring minerals containing soluble sulfate. As shown previously, the waste rock dumps throughout the Barneys Canyon project will either be neutral because of the balance between acid generating and acid consuming materials or, as in the case of Barneys pit mine waste dumps, be generally of higher pH. Sulfate may be present in the Melco and South Barneys South waste dumps, but will not be present as an environmental contaminant because of its immobility within the system. Sulfate is not expected to be mobile because of the limited influx of water into the dump due to its configuration, the neutralizing potential in the dump, and consequent low sulfate solubility.

Sulfate mobilization is partially dependent upon chemical reactions within the dump and on infiltration of sufficient water to move the sulfate out of the dump. Oxidation of sulfide minerals to produce sulfates is limited by chemical kinetics within the system. Kinetic test data previously submitted shows that oxidation is slow, if the material is sufficiently mixed with acid consuming material. With adequate mixing of waste materials, the dumps remain at neutral pH or slightly higher, thus reducing the solubility of sulfate within the system. Appendix 1 shows the results of shake flask tests which show the net pH of the waste to be above 8, even if exposed to slightly acidic solutions. A neutral pH inhibits the dissolution of the sulfate minerals, limiting the ultimate concentration of sulfate in solutions. B9

A more important consideration in determining whether sulfate will be mobile in the waste dumps is the physical configuration of the dumps. The relative density, permeability of the dumps and underlying strata, evaporation rates and topography all affect the amount of infiltration of precipitation into the dumps and consequently the potential for exfiltration from the dump. ←

Figure 1 shows potential water flow paths in and around mine dumps. The waste dumps are all located well above the regional groundwater table, therefore the only potential transport mechanism is through precipitation and infiltration. At the Barneys Canyon Mine, infiltration of precipitation is very low, and that infiltration is not evenly distributed within the dumps. This reduces the potential for dissolution of sulfates if they are present. Each of the flow paths is described below:

- 3.1 Precipitation/evaporation: The Barneys Canyon Mine is located in an arid area, with annual average rainfall of 16". The site also experiences a high evaporation rate, which directly affects the amount of water available for infiltration. Evaporation of precipitation is not restricted to surface evaporation as water is retained in

APPENDIX 1

Shake Flask Extraction Test Results

Leaching Solution:

	HH 1,2	HH 10,9,4,8,7
pH	4.20	4.20
Conductivity (umhos/cm)	21.70	
Sulphate (SO ₄) (mg/L)	4.2	2.0

TEST RESULTS:

Parameter	HH1	HH2	HH10	HH9	HH4	HH8	HH7
pH (after 1 hour of contact)	8.60	8.20	7.87	6.81	6.96	6.19	6.07
pH (after 2 hours of contact)	8.60	8.20					
pH (Final)	8.40	8.20	7.89	7.62	7.95	7.29	7.41
Conductivity (umhos/cm)	192.0	177.0	631	542	120	56	312
Eh (mV)			256	263	253	271	254
Alkalinity (mg/L CaCO ₃ eq.)	43.0	30.0	38.5	16.5	38.5	5.5	13.8
Net Sulphate (SO ₄) (mg/L)	22	20	41	46	17	32	44

METALS:

As	mg/L	0.05	<	0.05	<	0.01	0.03	0.06	0.13	<	0.01
Ba	mg/L	0.30		0.10		0.03	0.065	0.15	0.28		0.06
Ca	mg/L	21.00		10.00		21.22	15.58	11.56	4.32		19.75
Cu	mg/L	< 0.01	<	0.01		0.032	0.004	0.024	< 0.002	<	0.002
Fe	mg/L	< 1.00	<	1.00		0.09	0.36	1.33	7.63		0.32
K	mg/L	5.00		5.00		10.79	9.75	2.91	5.81		9.87
Mg	mg/L	4.00		2.80		5.73	2.51	2.54	1.48		3.88
Mn	mg/L	< 0.01	<	0.01		0.010	< 0.005	0.010	0.020		0.010
Mo	mg/L	0.34		0.02		0.13	0.05	0.20	0.02		0.03
Ni	mg/L	0.05		0.04		0.010	< 0.005	0.010	0.020		0.015
P	mg/L	< 1.00	<	1.00	<	0.01	0.02	0.20	0.08		0.05
Pb	mg/L	< 0.05	<	0.05	<	0.002	< 0.002	< 0.002	0.026	<	0.002
Zn	mg/L	< 0.01	<	0.01		0.012	0.016	0.023	0.093		0.027

* Selected metals not included (metals where the solids content was below detection limit)

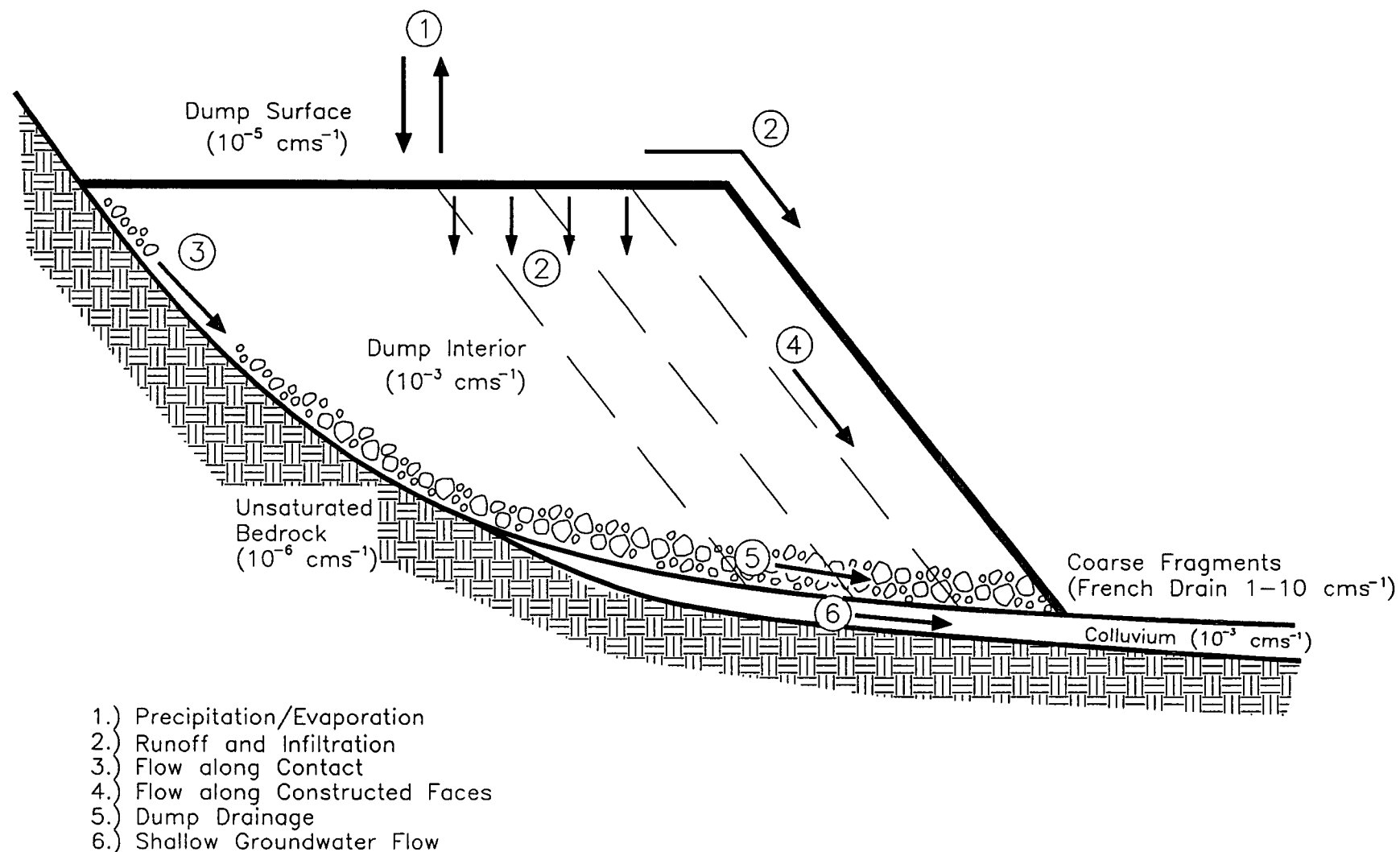


FIGURE 1
COMPONENTS OF DUMP DRAINAGE

the upper surface of the dump and subsequently evaporated. Ultimately, at closure, vegetation cover will also enhance evapotranspiration.

- 3.2 Surface flows - Much of the precipitation on the dumps reports as surface runoff. During active use of the dump, the top is maintained flat to accommodate the vehicular traffic. The dump surface is compacted by normal traffic flow and road maintenance activities such that the surface permeability is reduced to about 5×10^{-5} cm/sec. Drainage ditches divert water as needed to prevent ponding. At closure, the top of the dump will be configured so that it slopes to diversion channels or to gravel filled intercepting trenches which allow water to drain directly into colluvium thus routing precipitation around the dump.
- 3.3 Preferential flow along contact - An important water control mechanism in the dump design is drainage along the natural ground/dump interface. Drainage from above the dumps generally continues along the natural topography, entering the dump at the interface. Part of the management strategy will be to intercept this water and direct it around dumps where possible. In the naturally steep topography at Barneys Canyon, the water which is not redirected will preferentially flow along this interface without dispersing into the dump. This may result in short lived local washing of sulfates but the volume flow will be small and because of the short contact time, concentrations would likely be moderate (up to 500 ppm SO_4). In a relatively short time, the exposed sulfates will be rinsed out of the interface zone resulting in background levels of sulfate concentration in the flow.
- 3.4 Constructed benches and faces - During dump construction, the top is compacted and maintained for vehicular traffic. This compaction occurs as a result of continuous vehicle traffic and frequent grading to assure a flat, compacted bench. This compaction results in a very low permeability material. Evaporation is enhanced because of the low permeability and runoff will be directed to the intercepting trenches described in (2) above.
- 3.5 Dump drain in an end-dumped waste pile - Large waste rocks preferentially segregate at the bottom of the pile. In the steep terrain of the Barneys Canyon Mine, the preferential segregation results in a French drain type

system with very high permeability. This drain is continued with every advance of the dump face and serves as a collection system for water which may migrate through the dump. Slowly migrating solution may attain sulfate concentration of about 2,000 ppm if the flow path is long enough, however water flow in dumps tends to be along channels and so long contact paths are not expected. The exact concentration of sulfates will be controlled by the relative amounts of calcite or dolomite in contact with solution and by the contact time. It is believed that all of the waste dumps at Barneys Canyon will remain unsaturated and that solution released would be very small volume because of low infiltration into the dump.

- 3.6 Shallow groundwater flows - While there is no generally accepted model available to account for all the complexities of water movement through mine waste dumps, there are many factors at Barneys Canyon Mine to inhibit infiltration of water into the dumps, and it is doubtful that saturation of the dump could occur. The present dump construction practices inhibit infiltration of precipitation and reduce the potential for sulfate mobility. These construction methods may be enhanced with selective waste management and closure practices to further reduce the potential for sulfate mobility.

4. MANAGEMENT PRACTICES TO PREVENT ACID GENERATION AND CONTROL SULFATE MOBILIZATION

- 4.1 The primary control mechanism will be to ensure good blending of sulfidic waste with neutralizing waste.

Sulfide material is easily identified by color and in general, waste containing greater than 0.1% sulfur is visually distinct. Thus it is easy to see whether sulfide waste is being spread over a dump face. In the normal course of dumping, the waste will form a thin veneer across the length and width of the active dump face. This veneer would normally be less than 6" thick except for occasional larger rocks. Subsequent dumping of non-sulfide waste on top of the sulfide will ensure intimate contact of neutralizing material with sulfide waste, as seen in vertical cross section.

Management control will be:

- i. To schedule mining and dumping so that sulfide concentrations do not occur in the waste dumps.
 - ii. To ensure that sufficient dumping width is available to guarantee that the sulfide veneer will not exceed 6".
 - iii. To ensure that the final dump surface is covered by at least 4 feet of non-sulfide bearing waste including the topsoil cover.
- 4.2 Secondary control will be to ensure that infiltration of rain water or snow melt into the dump is minimized. This will be accomplished by:
- i. Contouring the final dump surface and compacting it to promote run off.
 - ii. Applying topsoil to the dump surface and re-establishing vegetation in accordance with the mine reclamation plan.
 - iii. Diverting surface runoff around dumps where feasible.
 - iv. Surface drainage will be controlled to reduce dump face erosion.
- 4.3 A proposal has been made to construct a process plant to treat sulfide bearing ore. This plant should be operational by the fourth quarter of 1994. Efforts will be sustained towards treating the maximum economically

feasible quantity of sulfide material at this plant thus minimizing the quantity of sulfide reporting as waste.

- 4.4 Map areas of sulfide mineralization in final pit configurations - The quantity of sulfide material exposed in the final pit wall can be estimated. Once the mapping is complete, the final reclamation plan for the pit walls can be completed. Preventive actions may include filling the pits with water to prevent oxidation, sealing pit walls or overexcavating in selected areas to reduce exposures.
- 4.5 Continue with revegetation test plots - As part of the evaluation of revegetation methods, surface permeabilities will be measured as an added criteria in determining selected revegetation techniques.
- 4.6 Engineered crest design for each dump prior to completion of dumping. This will be based on site specific topography, infiltration testing and evaluation of precipitation events. These designs can be submitted to DWQ if requested prior to dump closure.

References:

Olesen, M.H. (Letter to Mr. W. C. Dodge), Ref. "Stockpile Test Results" 1992

Robertson, A.M. (Letter to D. I. Hodson) Ref. "Acid Base Accounting and Shake Flask Test Results" March 18, 1993

Robertson, A. M. (Letter to D. I. Hodson) Ref. "Summary of ABA Accounting Results from the Melco Deposit" April 15, 1993